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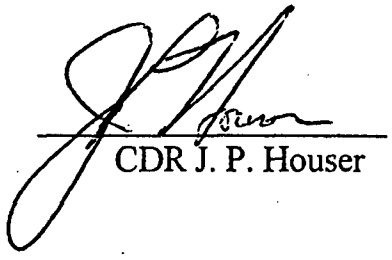

CDR J. P. Houser

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16 May 02

# From Prowlers to UAVs: A Bridge Too Far for Airborne Electronic Warfare?

**Prologue**

*October 2014. RADM Napoleon "Nap" Trotter, USN, took a deep breath and indulged in the night's crisp high-altitude air as he stood outside the Combined Air Operations Center (CAOC) in central Jihadistan.[1] Both apprehensive and assured, he readied himself to brief his staff on the coming air suppression missions. A veteran of four air power campaigns in the Greater Middle East (Gulf War, Kosovo, Afghanistan, and Tajikistan in 2009), he had every reason to be confident. He thought of today's major difference and smiled. For the first time, this attack would harness electronic warfare (EW) provided by something other than the venerable EA-6B Prowler aircraft. Having worked extensively with the new Battlefield-Link Attack System (BLAST) during the last decade, he was ready to see it perform in combat. Professionally confident, he was personally grateful to past planners for its bold introductory vision back in 2002.*

**Introduction**

What is the post-Prowler (EA-6B) future of airborne electronic warfare?[2] As the two-year, Navy-led joint study Airborne Electronic Attack- Analysis of Alternatives (AEA/AoA) languishes in the Office of Secretary of Defense in the Spring of 2002, what transition path should be approved? A skeptic assumes Pentagon a report of "business as usual," with neatly packaged power point slides recommending an evolutionary USN/USAF airframe and mission sharing. But is that destiny? This paper proposes electronic warfare (EW) could consist of modest airframes carrying robust interchangeable sensors linked together and directing new munitions. In short, EW needs a new network-centric approach to enemy air-threat suppression.

The timeframe to be examined in this paper starts in 2015, based upon the projected end-of-life for the EA-6B Prowler. A window of fifteen years is viewed based

upon the unsupported but plausible assumption that by 2030 EW will be conducted primarily by Unmanned Aerial Vehicles (UAVs). Therefore, given this timeframe between 2015 and 2030, a network-centric foundation is postulated as the next EW structure, bridging the gap from Prowlers to the future. To examine this possibility, first a brief history of EW will be offered, concentrating on the lessons learned from the 1999 air campaign over Kosovo. Next, present forces and proposed modernization possibilities are listed to define the trends in EW. Lastly, a skeleton system for Network-Centric Warfare (NCW) applied to EW is offered, including organizational changes required to achieve a viable system in a decade.

**Air of Superiority**

The necessity of adaptable EW in modern air warfare became apparent at the onset of the Vietnam War. Opposed by North Vietnamese use of Russian-built SA-2 surface-to-air missiles (SAM), initial strike sorties struggled with this new threat, including several shoot-downs in the summer of 1965. EW came to the rescue. A slow, lumbering propeller aircraft (F-100F) was outfitted with radar-jammer that suppressed enemy detection and SAM-guiding radars.[3] A tribute to innovation, this Wild Weasel system deployed to the theater in only seven months, including a 2-month testing phase.[4] Even while constrained politically, as LBJ was concerned about killing Russian technicians helping the SAM operators, the success of EW had changed the enemy tactics a year later.[5] Due in part to this new equipment's suppression capability, few radar-guided weapons hit US aircraft after 1966; in fact 85% of US losses were due to anti-aircraft artillery (AAA) and heat-seeking (infrared) SAMs.[6]

Successes continued into the Gulf War, despite the aging of the 1960s EW technology. F-4G Wild Weasel-II electronic warfare aircraft were used extensively, as EW platforms were tasked on almost every sortie during the air campaign. After losing eight aircraft in the first week to radar-guided SAMs, the allied forces lost only five in the rest of the War.[7] Tactics on both sides shifted to attempt to exploit weaknesses. Iraqi air defense installations minimized their radar use after suffering huge losses during the first few days. About 30% of Iraqi SAM sites were destroyed during the war, and most in the early stages. Unguided SAM firings continued until the last day.[8] On the coalition side, after initially flying low and fast to avoid enemy radar detection, air crews shifted to higher altitudes because of the greater threat of AAA and small arms over radar detection and SAM vulnerability. Thus, the conduct of the air campaign was impacted even by unsuccessful air defenses, as non-standard SAM employment countered superior technology.

**Air of Vulnerability**

Though the 1999 Allied Force campaign in Kosovo reinforced EW's undeniable link to air power's effectiveness, it brought into question DoD's choice of packaging most of EW into the Navy's EA-6B Prowler airframe. Several lessons arose. First, no attack sorties were flown without EW support.[9] Second, the 4500 EW sorties (of 38,000 total) were flown by a markedly reduced number of EW assets.[10] World-wide EW assets were marshaled to Kosovo resulting in "gaps" in standard coverage in Northeast Asia and the northern Iraqi no-fly zone.[11] Third, enemy innovation countered standard EW tactics. No doubt observing the lessons from the Gulf War, enemy operators minimized their transmissions at the outset, employing a "peek and shoot" method that lessened their

defensive losses.[12] As opposed to the 30 % destruction of air defenses in Iraq, the Serbs lost only 2 of 22 sites. Admittedly, only 2 of the 700 SAMs fired from these defenses found their mark. However, most sites were not destroyed, a notable difference from other campaigns, attributed largely to enemy SAM operation and more difficult terrain. Fourth, the Serbian forces used the next-generation of air defense sites- the so-called "double-digit" SAMs (SA-10, 11, 12, 13). These weapon systems proved more formidable, and mandated adjusted Allied tactics.[13] Of note, to minimize aircraft loss, attack sorties were flown at high altitude, and helicopters, the Army's principle mobile firepower provider, were not used at all. Lastly, driven by the relatively few EW assets and their importance in sortie protection, the availability of Prowlers and other multi-mission EW aircraft governed the pace of the attacks. This self-imposed throttle control was evident to the planners, and restricted the pace of the offensive.[14]

The limitations of EW highlighted in Kosovo did not go unnoticed. Both inside and outside of DoD studies are being conducted to gage the magnitude of the problem, the rate of decline, and possible corrective actions needed. Several concerned former military pilots in Congress have formed the Congressional EW Working Group.[15] Electronic warfare, with the elimination of several platform types and the US's frequent use of air power, is by definition a low-density, high-demand (LDHD) asset. Such designation is defense-speak for a "national asset." Though this moniker can be carelessly applied, it is no overstatement in application to EW. A review of each service's EW status will present US EW capabilities and trends.

In total, the Navy and Marine Corps operate 19 EA-6B Prowler squadrons, with the Navy units operating four planes per squadron and USMC assets fielding five. These

razor-thin squadron complements are hardly robust, as one Navy squadron in Kosovo could not operate when one of its four planes was grounded.[16] The Prowler force is stated to be 124 aircraft, yet only 82 are available now as some platforms are being modified or awaiting depot maintenance.[17] Understandably, the Navy's number one EW priority is improving readiness. The second through fourth priorities are all related to capability upgrades: buying the improved capability processor (ICAP-III) which brings next-generation radar jamming and real-time reactive (vice preemptive) suppression;[18] enhance existing jamming capabilities, especially in communications; and finally fielding Link-16 for improved connectivity with friendly battlefield assets.[19] These pursuits will prop up the still-capable Prowler, despite airframe operating and maintenance costs that have risen 55% in last 2 years.[20] Some have touted these electronic upgrades as "supporting Network-Centric Operations" because of their connectivity.[21] The Marine Corps Prowler fleet, though critical to air power across the joint spectrum, gets increasingly mixed reviews within the Corps itself. Like politics, all service loyalty is local, and with the marked reduction of ground support missions in Prowler taskings, the Corps is openly debating its proper function.[22] Follow-on proposals for Navy EW are congealing on the Boeing-offered solution of a new platform from its F-18 line- an aircraft designated the F-18G Growler. A two-seater, this platform is viewed as a potential replacement in kind for the EA-6B.[23] The Marines, not currently flying the F/A-18 Super Hornet, are likely to wait on the JSF variant, and analyze it for any EW transition possibilities.[24]

The Air Force, which doesn't operate specialized EW assets per se, does supplement four Navy EA-6B squadrons with about a fifth of their total pilots, making

these Navy Prowler squadrons truly "purple." Demonstrating its multi-mission mindset, the USAF uses F-16CJ fighters employed primarily in suppression of enemy air defenses (SEAD). Recent procurement increases have taken the CJ fleet to over 225 planes.[25] Justification of increased F-16CJ production was buoyed by a post-Kosovo assessment of stealth technology's increased battle effectiveness when coupled with EW. Glaringly, the one USAF stealth asset lost in Kosovo was a F-117 operating outside its EW support.[26] Projections for USAF follow-on EW pursuits are less uniform than the Navy's and much experimentation continues in weapons and sensors. This hedging does not eliminate a platform-replacement mentality, but does show a willingness to look outside its present "box." Some propose back fitting older bombers, like B-1s and B-52s with present generation EW gear.[27] Other innovative thinking may be driven in part by the USAF's action to recently stand up a dedicated EW office (XOIE) within its Air Staff.[28] Lastly, a note on the Army. With the threat over Kosovo preventing the use of helicopters, the Army has recently commented it may consider in-house EW to ensure its availability use for ground support.[29]

In summary, present programs and doctrine within the services appear muddled in an effort to define the future. This is natural bureaucratic wrestling over a difficult cross-organizational problem. Although competition amongst multiple paths is healthy for maintaining multiple-service EW capabilities, the cold truth is platform flexibility has been programmed out with the removal of all specialized EW assets but the Prowler. The intractable question of "Which platform?" is only more complex when the different service priorities are observed.

**Air of Uncertainty**

Given these service-specific efforts, what should be the proper future of EW? For force planners, the two principal alternatives are to find a platform to replace the EA-6B or to shift to a linked system of sensors, shooters and electronic support architecture to conduct EW.[30] This latter approach, an application of Network Centric Warfare (NCW) is advocated here. To outline this concept, I will address the probable near-term threat, examine some theory associated with NCW, list some pieces of the future EW technologies, and finally examine organizational changes necessary to enact the transformation recommended.

Expanding on threat assessments from the Kosovo conflict, the evolution of electronic warfare is postulated as increasingly high-tech, mobile, and asymmetric in nature. With the proliferation of available electronics encouraging cheaply obtained systems, increased availability of post-Soviet SAM hardware, and even "battleforce-centric" air defense systems arising,[31] the capability of enemy air defenses will only improve. The difficulty in transition from first-generation to "double digit" SAM sites is a precursor to the flexibility necessary for US EW in the future. Also, the tactical employment of air defenses will change quickly, as each use of air power, even in limited campaigns, populates the enemy's database with lessons learned. One tactic certainly to be exploited is mobility, either in actual repositioning, or in discrete use of active emissions, further shrouding the air defense location. This vexing problem of destroying light, lethal targets that move with regularity has been a focus point of US military doctrinal concern for over a decade, with little confidence gained. One solution pursued in the subset of mobility applied to EW is the desire to shift focus from suppression to

destruction. Killing an enemy air defense site, (Destruction of Enemy Air Defenses, or DEAD) is displacing the traditional SEAD.[32] As successful as SEAD doctrine has been, it no longer enables the degree of superiority mandated in protracted, minimally attrited attack campaigns. As this mobility-technology marriage brings highly capable hand-held air defense weapons to common foot-soldiers, the US's existing blood and treasure personified in a two billion-dollar B-2 and its crew is flatly too valuable to continue to risk over vulnerable ground, even with minuscule kill ratios.

Lastly, the coming threat will be marked by missile forces vice air forces,[33] as US adversaries look to attack our dominate air power asymmetrically. Air-to-air engagements can be measured on one hand in the last decade,[34] despite extensive use of air power, and the inconsequence of such encounters will continue in the near-term. The realization of air power on the cheap- supersonic missiles with albeit minimum guidance- will be the weapon of choice for near-term adversaries. Any belligerent's attempt to achieve air superiority will likely appear as access-denial via defensive and offensive missile use.

**A New Approach**

Given this near term threat picture, how does the technology of networks help? Certainly the slick employment of the microchip will not displace the primacy of force, time and space as the dimensions of the battlefield. Before outlining a network-centric approach to the follow-on EW problem, one expansion of the theory of NCW is in order.

The time dimension of the battlefield takes preeminence.[35] As quoted in a recent DoD study:

"NCW is a shift in focus from the physical domain trumpeted by classic attrition theory and the spatial dimension expounded by classical maneuver theory to the temporal dimension."[36]

As often noted, the production of an "information backplane", robustly populated with extensive battlespace information and sensors, provides the principle temporal advantage over an enemy. This speed is the essence of offensive EW, as processing targets and delivering weapons quicker than the enemy has defined success since the 1960s. This thrust of theoretical NCW fits well into the operational battlefield necessities of EW.

**NCW EW- Technological Needs**

The future of EW could be moderately priced jets, carrying interchangeable sensor and communication pods, linked to local or remote SAM destruction missile shooters. Each of these subsets will be taken in turn.

Shifting away from platform-centric electronic warfare does not remove the need for a platform. To bridge from Prowlers to UAVs, use of a moderately capable 2-seat jet would act as the mobility asset for EW. The platform has several criteria: Joint-capable, including a carrier-based Navy variant; two-seated to support an EW specialist and free up the pilot to maximize situational awareness and all-weather avionics needs; and relative low-cost fixed-wing agility, to lessen exposure to threats and expand detection horizon. One possibility would be to use older 2-seater F-18Bs. They are familiar to the Fleet, capable in speed, range, and payload, and are becoming available as they are replaced by F/A-18E/F Super Hornets. While certainly viewed as a "poor man's innovation", use of this airframe will deliver the requirement: to carry sensors and weapons.

Though sensors continue to be the weak link in the "detect to engage" process, several electronics systems exist today to adequately carry the EW mission over our adversaries for the coming decade.[37] Yet these tools have been inadequately funded and insufficiently tested to ensure overall capability and compatibility with other assets. Inserting present and emerging sensor technology into uniform packaging is essential. Beyond the necessary informational interoperability, these sensor pods must initially be interchangeable between units, to support necessary "massing" in theater to produce a network. Subsequently, multiple pods will be necessary for redundancy and multi-functions within the network (i.e. sensor and shooter and communicator). Examples of linked sensors are here today, as both the Navy and the Army have deployed network-centric systems in combating air threats.[38]

Weapons systems must become cheaper, driven fundamentally by migrating smart capabilities out of the weapon and into the network. Rather than building highly capable seekers into missile warheads, the requirement is weapons able to download necessary seeker information. Thus, "dumb" weapons linked to the network become "smart" en route, either by traditional organic sensors, or more likely, updated intelligence from the network. This flexibility makes a "dynamically smart" weapon.[39] Today, concerns have arisen over the size of weapons, as gross weight must be minimized to allow moderate lifting capability. As information migrates from the weapon to the network, weight-reduction will be further enhanced. Also, cost savings are dramatic when shifting the technology out of a modern, SAM-killing missile, which is still a one-way, non-recoverable bullet. Despite launching over 1000 HARM missiles in Kosovo, only a handful of enemy targets were hit.[40]

**NCW EW- Organizational Needs**

NCW cannot be successful merely by imposing a highly capable information network over an existing architecture. More important than the use of the building blocks above, several key changes must occur. The military must transform its EW operational concepts, doctrine, and organization.

At the operational level, like all other warfare, EW is still an art, not only a science. Getting away from multi-mission, single-seat platforms, like the USAF's F-16CJ will markedly enable the warfare concentration necessary to develop the operational concepts of future EW. Fundamental is the understanding of what EW is to be: Is it timely suppression, or rather full destruction of air defenses? Is it even more dominant- a continuous and unrelenting full spectrum scepter placed over the battlefield that illuminates friendly and clouds enemy perception? And how does emerging EW view the traditional support of ground troops- of little consequence or significant? The prioritization of questions like these will form the structure under which EW warfighters can complete more tangible operational details.

With respect to doctrine, extensive experimentation must be supported. Insertion of technology has often bypassed existing doctrine, which works to conform the enhanced capability to existing axioms and ultimately underutilizes it. As well, the "opportunity for failure" must be tolerated. Intellectual honesty easily agrees with the need for mistakes in adjustments, but traditional bureaucracies do not. To penalize failures is to mutate experiments into exercises that fully entrenches any progress solely in the present.

Lastly, the organization must adjust to effectively apply the new technology in EW. Acquisition processes need to be viewed for what they are- ways to improve defense, not ends to be protected at all costs. Program managers must be reassured in their efforts to avoid the sheparding of sheep that should be slaughtered, for such programs effectively undermine other emerging programs via opportunity costs. DoD should consider the congressional input to centralize EW within a joint office with budget control for all the services.[41] A potential example of centralization could be the USAF's consolidation of space for DoD.[42] In fact, as EW continues to evolve through the timeframe after the Prowler into the realm of UAFs, it could be subsumed into the space organization of the future. Though such a jump is inappropriate today, development of a new EW Program Office within JCS should not be discounted as merely a bureaucratic move trumpeting efficiency over effectiveness. Without defined goals and adequate resources (i.e. real budget presence), no warfare specialty will be effective.

**Probable Arguments**

Opposition to a netted EW force will come from three concerns: technology, organization, and philosophy. These first two are inextricably linked. As alluded to above, the maturation of needed technology for military application of netted forces exists today, much less by 2015. A more insightful critique may ask why UAV use in EW must wait until 2030? The technology will no doubt be ready sooner, as in many military changes, but the second concern over organizational acceptance governs the speed of any technology insertion. The real hurdle for change is in the minds of the warriors of today. Modifying an organization already over-taxed in its present

configuration is unthinkable to some. Yet this change is most important for success, as it sets the tone for the future, from tools to application to mission assignments.

Nested within the organizational change is the conviction that a netted EW force will be undone by the lack of a specialized airframe. This misunderstands the principle weapons of EW- they are electronic not aeronautic. Just as the lumbering F-100F was Wild Weasel's initial EW platform in Vietnam, success in the electromagnetic spectrum can be obtained with many aircraft, given adequately capable sensors and shooters. Use of the F-18B mimics EW's embryonic airframe-to-electronics match and would be capable via upgrades to bridge the airframe gap to exploitation of UAVs.

To locate philosophic arguments opposing the netting of EW forces, one only has to review the burgeoning and mostly well-reasoned arguments given to date against NCW. Many critiques highlight the contradiction of NCW to the theory of war. Based upon Clausewitzian theory of War, battle cannot be reduced to a system.[43] When application of enhanced technology is seen as the desired outcome, the effects of fog and friction are denied their full measure. Also, opponents properly assert that actual combat, unlike virtual reality, is extremely chaotic, and includes psychological as well as physical stress.[44] Forgetting this aspect of the nature of war we do "at our peril."[45]

As applied to EW, however, the developed network is a tool, not an end state. This tool enables increased speed, accruing benefit to the user as the classical battlefield dimension of time ticks heavily in the user's favor. Netted assets provide enhanced ability to get inside the defenses' "hand of cards" by more rapidly knowing what cards he's fingering. Such speed does not dispel fog, but it does lessen its density for a friendly

force. As envisioned, the tool migrates data to information to knowledge, but it does not enable, as some proponents say, an outcome independent of an operator.

Friction is the struggle in making orders become action. As the fog of war is classically countered by situational awareness, friction is attacked using command and control.[46] Though some improperly purport NCW impersonalises war and thus negates friction, this forgets that enemies are human, not merely machines. Yet NCW does reduce friction via the network's ability to "lock out" opponent options.[47] In enemy air defenses, platform-centered sensors and shooters attrite enemy capability in a linear fashion, where additional sorties provide correspondingly increased damage. Yet a netted EW force destroys emitting threats much quicker, as the faster knowledge addressed above is acted upon. Rapidly, the viable options open to the enemy are being reduced. Because of the shock effect of the large delta on the left of these curves, similar to massed force impact in classic warfare, the enemy senses annihilation and pursues survival not attack.[48] Such a dilemma is a lock out. Clausewitz parallels of war to a card game, where both chance and enemy intent must be engaged. Locking out an opponent equates to limiting his draw to one card vice three when discarding.

**Conclusion**

The extensive use of air power in the last three decades has shown the importance of EW- it is the enabler of US air forces. Yet the recent history also shows us much vulnerability in EW. Technologies are available today to integrate EW assets, developing a system less burdensome as the existing LDHD Prowler asset. Now is the time to move EW away from a Prowler replacement in kind, and adjust the organization, practice, and art of EW to use netted sensors and shooters. Our air forces after next depend upon it.

**Epilogue**

Returning to our protagonist, RADM "Nap" Trotter, we can envision this force-planning result at the successful conclusion of his three-week campaign in Jihadistan. Here he reads an award citation for Navy EW squadron, VEW-123, one of the EW commands chopped to the Joint Commander:

*By virtue of the authority vested in me as President of the United States and as Commander-in-Chief of the Armed Forces of the United States, I have today awarded*

*THE COMBAT ACTION RIBBON*

*FOR EXTRAORDINARY HEROISM TO*

*The United States Navy Element of the*

*JOINT AIR OPERATIONS (VEW-123)*

*For extraordinary heroism and outstanding performances of duty from 25 September through 15 October 2014 while engaged in armed conflict over Jihadistan.*

*Developing a real-time, commonly displayed picture of the Jihad battlespace only hours after being directed in country by the President, VEW-123 linked sixteen Army, Navy, and Air Force airborne platforms via the Battlefield-Link Attack System (BLAST). Quickly destroying the balance of rapidly mobile anti-air targets by issuing adaptive guidance to standoff weapons, VEW-123 minimized exposure of US airmen during the initial suppression, subsequent reactive strikes and the resultant ground troop campaign. By employing both passive and active detection methods and directing varied munitions upon enemy forces, VEW-123's proven tactical acumen, honed in frequent state-side experiments, violently countered several innovative but ultimately futile air defense tactics attempted by the enemy. Judiciously maintaining vintage airframes like the F/A-18B, VEW-123 personnel freed up resources to augment existing training producing tightly defined requirements to better develop the BLAST system before its fielding last year. Principally due to their destruction, vice mere suppression, of air defenses, VEW-123 enabled a minimal strike force presence, providing an effective use of assets in Jihadistan and efficient use of continuously engaged forces elsewhere around the globe.*

## Endnotes

[1] Philip Gold of Discovery Institute coined this name of a fictitious nation. See Mackubin Owens, "Jihadistan- Ways to beat a determined enemy", *Providence Journal*, 18 September 2001, B5.
[2] Electronic Warfare includes both offensive and defensive components, portioned into electronic attack (EA), Electronic Protection, and EW Support" per *JCS Pub 1-02: DoD Dictionary of Military and Associated Terms*. Suppression of Enemy Air Defenses (SEAD), though not a delineated subset, is a mission area that harnesses EW. Of note, at the tactical level, the Navy is prioritizes EA, and the USAF prioritizes SEAD.
[3] The initial EW installation to suppress Vietnam SAMs, dubbed the "Wild Weasel", was installed on the F-100F aircraft. This plane was chosen because it was immediately available and it was a two-seater, enabling the placement of an EWO in the back seat. See William A. Hewitt, *Planting the Seeds of SEAD-The Wild Weasel in Vietnam* (Maxwell Air Force Base, Alabama: Air University Press, 1993), 9.
[4] Ibid., 10.
[5] Ibid., 2.
[6] Eliot A. Cohen, Director, *Gulf War Air Power Survey* (Washington D.C.: Government Printing Office, 1993), Vol. 3, Part 2, 143.
[7] Ibid., 141.
[8] Ibid., 139-40.
[9] Thomas W. Hofer, "Bring the Prowlers Home," U.S. Naval Institute *Proceedings*, August 2000, 33.
[10] EW sorties comprised 4,500 of 38,000 total in Kosovo. Two of 900 allied aircraft were shot down and 2 of 22 Serb SAM batteries were destroyed in the 78-day campaign. See Christopher Bolkcom, "Airborne Electronic Warfare" Issues for the 107th Congress," *CRS Report to Congress*, 9 February 2001, 5,7.
[11] Daniel Goure, "The Resource Gap," *Armed Forces Journal International*, May 2000, 40.
[12] Christopher Bolkcom, "Airborne Electronic Warfare: Issues for the 107th Congress", *CRS Report for Congress*, Congressional Research Service, February 9, 2001, 6.
[13] SA-10s are long-range/high-altitude area denial weapons posing significant challenges to EW planners. See Walter Hudson, "SAM Threat Over Iraq," U.S. Naval Institute *Proceedings*, October 2001, 32-33.
[14] Jonathan Marcus, "Kosovo and After: American Primacy in the Twenty-First Century," *The Washington Quarterly*, 23:1 (Winter 2000): 82.
[15] "The Hill's Strongest EW Advocate: US Congressmen Joseph R. Pitts," *Journal of Electronic Defense*, May 2001, 47-51. See also the Working Group's website at http://www.house.gov/pitts/initiatives/ew.htm, accessed 10/10/01.
[16] Marcus, 83.
[17] Loren B. Thompson, "Shaping the Battlespace: The Future of Airborne Electronic Warfare," *Sea Power*, March 2000, 41.
[18] Mark Hewish and Charles Gilson, "Into the Valley of Death," *International Defense Review* 34, no. 10 (October 2001): 2.
[19] Bolkcom, *CRS Report*, 18.
[20] Gen. Henry H. Shelton, USA, testimony before Senate Armed Services Committee, September 5, 2001.
[21] RADM John B. Nathman, USN, testimony before Seapower Subcommittee of US Senate 23 March 2000.
[22] As national assets, the USMC Prowlers no longer are fully integrated with ground troops. This disconnect is viewed by some as a reason to take the Prowlers out of the USMC aircraft inventory to free up money for other functions. See Lloyd E. Bonzo II, "Parting with the Prowler," U.S. Naval Institute *Proceedings*, August 1999, 37, and John V. Moloko, "Let the Navy Do the Prowling," *Marine Corps Gazette*, December 2000, 42.
[23] Brendan P. Rivers, "The AEA AOA approaches: Super Hornet could give sting to electronic attack," *Journal of Electronic Defense*, August 2001, 28-9.
[24] Thompson, 42.
[25] William S. Cohen, Secretary of Defense, *Annual Report to the President and the Congress 2000*, Part II: Today's Armed Forces, 70.
[26] Thompson, 41.
[27] Steven Kosiak, Andrew Krepinevich, and Michael Vickers, *A Strategy for a Long Peace*, Center for Strategic and Budgetary Assessments, January 2001, 45.

[28] Bolkcom, *CRS Report*, 12.
[29] "Electronic Warfare- Comprehensive Strategy Needed for Suppressing Enemy Air Defenses", *GAO Report 01-28*, United States General Accounting Office, January 2001, 12.
[30] Thompson, 42.
[31] Michael Puttre, "New Thinking in Air Defense networks puts SEAD in Check," *Journal of Electronic Defense*, May 2001, 42.
[32] Gert Kromhout, "From SEAD to DEAD," *Military Technology*, December 2000, 8-15.
[33] Steven Kosiak, Andrew Krepinevich, and Michael Vickers, *A Strategy for a Long Peace*, Center for Strategic and Budgetary Assessments, January 2001, 44.
[34] Hewish, 1.
[35] "Tactically, speed is critical." See VADM Arthur K. Cebrowski, USN and John J. Garstka, "Network-Centric Warfare- Its Origin and Future", U.S. Naval Institute *Proceedings*, January 1998, 32.
[36] Booz-Allen and Hamilton, "Measuring the Effects of Network-Centric Warfare- Volume I", prepared for Office of Secretary of Defense, Net Assessment, 28 April 1999, 3-2.
[37] Two emerging systems in EW are the Advanced Tactical Targeting Technology (AT3) program and an ACTD called Network-Centric Collaborative Targeting (NCCT) being sponsored by CENTCOM. The former seeks to widely distribute amongst friendly forces passive radar receptions- a real-time targeting net of sorts. The latter attempts to network the varied sensors in existing aircraft, reducing CEPs and timelines to targeting. "In its most successful manifestation, ...AT3 will make dedicated SEAD aircraft unnecessary." See *CRS Report*, 15.
[38] Within the Navy, the Cooperative Engagement Capability (CEC) employs linked surface combatant assets to develop a battlegroup-wide air defense picture. Inorganic tasking of weapons is part of the system. See Brendan P. Rivers and Michael Puttre, "Victory at CEC," *Journal of Electronic Defense*, September 2001, 40-5. For the Army, an objective called Air and Missile Defense Planning and Control System (AMDPCS) is being developed to connect sensors and missile-launchers. This system will be tailorable to a specific force package for a given threat. See Puttre, "New Thinking in Air Defense," 40.
[39] David S. Alberts, John J. Garstka, and Frederick P. Stein, *Network Centric Warfare, Developing and Leveraging Information Superiority*, 2nd ed, (Washington, D.C.: CCRP Publications, 1999), 65-7.
[40] Randy Cunningham, "Suppression of Enemy Air Defenses: Improvements Needed," Issue Brief #7, 11 June 2001, available at http://www.house.gov/pitts/initiatives/ew.htm.
[41] "The Hill's Strongest EW Advocate", 47.
[42] The USAF has been designated the "... Executive Agent for Space within the Department of Defense" by SECDEF. See SECDEF letter to Senator John Warner, response to section 1624 of Pub. L. 106-65, 8 May 2001.
[43] Mackubin Thomas Owens, "Technology, the RMA and Future War," *Strategic Review*, Spring 1998, 65.
[44] Ibid., 67.
[45] Ibid., 64.
[46] Alberts, et al., *Network Centric Warfare*, 71-2.
[47] Cebrowski and Garstka, 29, 33.
[48] Booz-Allen and Hamilton, 6-13. Also see Alberts et al., 173-5 for an example applied to SEAD. This lock-out depicts the left side of this curve.